An ASSYRIAN TEXT *on* GLASS MANUFACTURE

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Studies of the many authentically dated specimens of ancient glass in museums and private collections have enabled investigators interested in the origin and progress of glass manufacture to reach some tentative conclusions on the succession of glass-forming processes. There is, however, a dearth of information on the chemical compositions of ancient glassware or the raw materials used by early glass workers.

R. Campbell Thompson in "The Chemistry of the Ancient Assyrians" (published in a limited edition in 1925) offered a careful translation of certain seventh century B.C. Assyrian cuneiform tablets dealing with glass compositions and melting technic. This work is reviewed and used as the basis of an estimate of the chemical knowledge of the Assyrian glass workers.

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ONE of the most famous examples of ancient glass manufacture is the small vase, originally transparent and faintly green in color, but now slightly opaque through surface decay, which occupies a place of honor in the British Museum and is described as "Glass Vase with Sargon's name and the lion device marking his property."

This vase was discovered in 1847 by A. H. Ledyard during his excavation of Nimroud, the site of an Assyrian palace some miles from Ninevah.

The Sargon vase, which is 90 mm. high and 40 mm. in diameter at the neck, is thus described by Ledyard[1]—

> On this highly interesting relic is the name of Sargon, with his title of king of Assyria, in cuneiform character, and the figure of a lion. We are therefore able to fix its date to the latter part of the seventh century B.C. It is, consequently, the most ancient known specimen of *transparent* glass, none from Egypt being, it is believed, earlier than the time of the Psamettici (the end of the sixth or beginning of the fifth century B.C.). Opaque colored glass was however manufactured at a much earlier period, and some exists of the fifteenth century B.C. The Sargon vase was blown in one solid piece, and then shaped and hollowed out by a turning machine, of which the marks are still plainly visible.

In the eighty years which have elapsed since Ledyard discovered and described the Sargon vase the archæologists have thrown new light on the probable origin of Egyptian glass, and discoveries in Mesopotamia have somewhat changed our views on the beginnings and the development of the manufacturing arts.

Careful studies of dated pieces of glass have also permitted the development of an approximate chronology of glass-working processes in ancient countries.

Ledyard's statement "blown in one solid piece" is either a curious blunder (for Ledyard knew something of glass technology) or an unintentional use of "blown" for "gathered," as the Sargon vase was undoubtedly shaped by carving methods from a solid block of glass. It is not therefore, as some authors have assumed from reading Ledyard and without examination of the vase, *prima facie* evidence of the existence of glass-blowing processes in Assyria in the seventh century B.C.

The Sargon vase, apart from its historical importance, has an interesting association with the chemistry of glass, as our present earliest record of glass compositions is derived from certain cuneiform tablets prepared under the direction of Ashurbanipal, who became king of Assyria thirty-six years after the death of Sargon, and imagination does not have to be brought into play to link the manufacture of the Sargon vase with the knowledge displayed in the Assyrian cuneiform textbook on glass technology.

In considering the handicraft products of the Assyrians it must be remembered they may have retained something more than a trace of the broad knowledge of the arts possessed by the Sumerians who, two thousand years before Sargon, were losing a twenty-five century control of Mesopotamia and passing under the successive domination of the Semites, Hittites, and Babylonians. The Sumerian civilization, as evidenced by the recent exploratory work of the joint expedition of the University of Pennsylvania Museum and the British Museum at Ur (the Biblical Ur of the Chaldees), was of a high order, and while a generation ago it was quite generally accepted that the earliest Eastern civilization originated in the Nile Valley, it seems probable that, as Langdon[2] says, after a careful survey of available evidence:

> The writer inclines to the belief that a great prehistoric civilization spread from Central Asia to the plateau of Iran, and to Syria and Egypt long before 4000 B.C., and that the Sumerian people, who are a somewhat later branch of this Central Asian people, entered Mesopotamia before 5000 B.C.

From the standpoint of information on the origin of glass manufacture, the Mesopotamian explorations have, up to the present, added no new data, as glass, except for some fritted beads found at Ur and dated as approximately 2450 B.C., does not appear in the lists of materials found in the Sumerian tombs and

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[1] A. H. LEDYARD, "Ninevah and Babylon," London, **1853**, pp. 196–7.

[2] "Cambridge Ancient History," 2nd ed., University Press, Cambridge, England, **1924**, vol. 1, p. 362.

debris heaps. However, archæologists have only begun the exploration of ancient Mesopotamia, and, providing the glass compositions were of the enduring kind and not, because of high alkali content, liable to age-decay, it is possible that we shall shortly be able to trace backward from the Sargon Assyrian example of 722 B.C. and the cuneiform text, to the much earlier periods when the breadth of knowledge indicated by the text was in process of development.

While the text on glass making was once part of the magnificent Royal Library at Ninevah assembled and transcribed under the direction of King Ashurbanipal (668–626 B.C.), it is not impossible that the text is an edited copy of a much earlier work, as certain other tablets, dealing with medicines, have been traced back to texts incised six centuries earlier.

To the zeal of Ashurbanipal as a collector and publisher of ancient works we also owe one of the most interesting poems in the world, "The Epic of Gilgamesh," a poem of undoubted antiquity as there are an existing Sumerian fragment (*ca.*, 4000 B.C.), three tablets in Akkadian (*ca.*, 2000 B.C.), fragments of a Hittite edition, and a single tablet from Ashur. The edition of Ashurbanipal (now in the British Museum) is in twelve tablets, each containing about three hundred lines in meter.

I have elsewhere[3] briefly reviewed Mr. Thompson's translation from the standpoint of glass technology, and in this present paper I propose to consider, as evidenced by the text, the chemical knowledge of the Assyrian glass workers of the seventh century B.C.

The translation of a cuneiform text, and more particularly a technical text, is a matter of extreme difficulty as it can only be approached by deductive methods which would do credit to Sherlock Holmes.

The procedures followed by Mr. Thompson will be evident from the following quotation.

> We may premise that, in all these texts dealing with glazes or glass, each receipt must surely contain some clear indication that the glass base, frit, strass, or whatever it be, is included. It must either be referred to definitely by name, or else its full components must be detailed, or, as a third method, the previous receipt containing the glass must be referred to (as in Pl. i, K. 203, vi, 4). I mention this because it is a most important clue to the identification of several ingredients, and yet I do not think it an unfair postulate, for we may surely regard these texts as having been made with great exactitude for the benefit of craftsmen of every capacity and degree. If we apply this postulate to the glass-receipts, we shall find that it will divide them into two classes marked respectively by:
>
> (1) The presence of such names for different kinds of glass as can be definitely identified from the components which are given in detail in the special receipts devoted to their manufacture.
>
> (2) The absence of such names of easily-identified glass among the components.

Starting with the lamentably few analyses of ancient glass which have been recorded, and the knowledge that lead was an unlikely component, the translator, by a comparison of the major constituents of the various compositions in the text, and through philologic parallels with Arabic and Greek words, has concluded that the starting point, or base, was an alkali-sand-lime glass.

If we take the proportions of raw materials in the base compositions and consider the sand and calcium carbonate to have been fairly pure, and the alkali to have had a soda content about the same as "Barilla" or "Rochetta" (both made by lixiviating salt-marsh grasses) we can reconstruct one of the glass compositions as very roughly 65% silica, 25% soda, and 5% lime—in other words, a nearly transparent but somewhat unstable soda lime glass. The identification of the alkali as a type of "Barilla," does not present the difficulties associated with the recognition of other materials in the text formulas, as the Assyrian word "*uhulu*" has its counterpart in the Syriac "*ahla*" which means a lye made from plant ashes.

It is apparent from a study of all the formulas that the Assyrian glass workers made up a practically colorless high-alkali glass as a semiraw material, and then by melting a given weight of the roughly powdered base with metallic oxides, etc., they secured the colored glasses which were worked up into the desired finished shapes.

The shaping technic is not described in the text, but examination of authentically dated Assyrian glass of the period suggests that while a blowing process was used at times, the gathering of molten material on a hollow pipe (the "punty" or "pontil" of the last several hundred years) was unknown. It seems likely that the glass was worked into rods, the rods wound around a removable core (probably sand), then the object was attached to a pipe, heated to the softening point, and worked to its final shape by free-hand methods. Many articles were, like Sargon's vase, shaped from solid blocks by carving, and from one sample now in the author's possession it seems quite likely the rough blocks of glass for carving were made by allowing a melt of glass, in a crucible or pot, to cool slowly, the pot being finally broken away from the glass.

The Assyrians were of course excellent lapidaries, and it was a very natural procedure to employ stone-cutting and dressing methods for shaping glass, and even to form glass intentionally into shapes like rough stone blanks.

To return to the text and the coloring substances used, Mr. Thompson furnishes competent evidence (even though largely by deduction) as to the occurrence in the texts of: manganese dioxide, ferric oxide, cinnabar, antimony sulfide, arsenic trisulfide, saltpeter, gold, copper oxide, tin oxide.

Mr. Thompson in developing the probable source of these materials has studied the minerals of Mesopotamia and, based on a location survey which indicates the first six items in the list were available in mineral form within 300 miles of Ninevah, he expresses the opinion that these substances should be considered as minerals and not manufactured products.

Some further confirmation on this point is provided by the texts themselves, as we find an incomplete de-

[3] *Am. Ceram. Soc. Bull.*, **7**, No. 1 (1928).

scription of the manufacture of copper oxide coming between a colorless glass base formula and a description of the making of a blue glass by the addition of copper oxide to the colorless base.

The Assyrian copper oxide process is quite reminiscent of Dioscorides, Pliny, and other later writers' descriptions of methods for making "flowers of copper."

The incomplete text calls for the melting of ten pounds of copper in a clean crucible (melting pot) set in a furnace where a "fierce fire is kept burning." The molten metal is spread and beaten out and placed on the roof (probably of the furnace).

Evidently the melting of the copper was a step in forming thin plates which were heated to promote oxidation and beaten to remove the oxide scale.

Another incomplete portion of the "blue glass" text seems to refer to a rough form of pyrometry, as the worker is instructed to "try" the furnace temperature by the time required for a stone jar of wine to reach the boiling point. Possibly the complete text, if it existed, would indicate that the stone jar was to be placed in a furnace outlet rather than in the furnace itself, as the temperature inside a glass-melting furnace would be too high for the successful use of a stone jar-wine thermometer.

It is interesting to compare the Assyrian temperature-measuring device with the sixteenth century A.D. method of timing the melting of a lead cube or cylinder in an iron "try pot" set within a furnace.

Perhaps the greatest surprise to the glass chemist is the appearance of gold as a coloring constituent in an Assyrian glass. The one formula having gold as a constituent refers to the final glass product as of a red coral color, and while we associate gold with ruby glass, Thompson points out the ruby was unknown to the Assyrians as also to the Egyptians.

The Assyrian glass workers were principally concerned with the simulation in glass of precious or valuable minerals, and as red coral is found in the Persian Gulf, it seems quite likely that coral was the material imitated by the opaque red composition.

The translation of the formula is:

7200 parts plain glass base 20 parts antimony (sulfide?)
32 parts oxide of tin ? parts salt (peter)
1 part gold

The gold content of the glass is therefore approximately 0.015%, which is in fair agreement with the gold content of modern gold-ruby glass.

The glass-melting operations of the Assyrians involved surprisingly large batches, as is evidenced, for instance, by the colorless base formula which calls for ninety pounds of raw batch for a single pot melt. The colored glasses were, however, made up in small batches ranging from one to four pounds, and possibly, like the later Egyptian glass of the second century B.C., these colored glasses were melted and worked in smaller furnaces.

The list of glass formulas runs the gamut of color from colorless through opaque white, yellow, green, three kinds of blue (blue was a favorite Assyrian color), red, violet, brown, and black; so, while we lack actual examples of several of these colors, we have text references to compositions which we can predict would give glasses of the various colors as they were named by the compiler of the tablet textbook.

We can even go some part of the way in predicting that the "green crystal" composition of the cuneiform text would result in a glass very much like the glass of Sargon's vase, and perhaps when the archæologists unearth other specimens of similar color we may be able, by analysis, to complete the identification.

The recital of Assyrian glass formulas and the raw materials employed is satisfactory evidence of the useful knowledge of glass chemistry possessed by the workers who gave their data to King Ashurbanipal's scribes for permanent preservation on incised clay tablets. Two thousand five hundred years from now these same clay tablets may still tell their story, but the twentieth century textbooks on glass manufacture will have turned to dust. The remote historian of the glass-manufacturing art may compare chemical analyses of archæological finds of our present-day glassware, but he will not be able to hazard the guess, as we have done with the Sargon vase and the cuneiform text, that some twentieth century A.D. blue glass vessel was made from the composition given on a page of a present-day textbook on glass manufacture.

(*Editor's Note:* A copy of the Assyrian text here discussed was included in the chemico-historical exhibit at the Library of Congress during the recent A. C. S. meeting.)